Earthquakes Caused by Dams:
‘Reservoir-Triggered/Induced Seismicity’

Reservoir-triggered seismicity (RTS), also referred to as reservoir-induced seismicity (RIS), is the triggering of earthquakes by the physical processes that accompany the impoundment of large reservoirs.

A leading scholar on this topic is Harsh K. Gupta who defines the occurrence as:

> **“…earthquakes occurring in the vicinity of artificial water reservoirs as a consequence of impoundment.”** (Gupta, H.K., 2002.)

Gupta, in his review of studies on RTS, highlights the following points:

- Globally, there are over 90 identified sites of earthquakes triggered by the filling of water reservoirs

- The largest and most damaging earthquake triggered by a man-made reservoir was in 1967 in Koyna, India. The magnitude of the earthquake was a 6.3

- Depth of the water in the reservoir is the most important factor in RTS. The volume of the water also pays a significant role in triggering an earthquake

- One characteristic of RTS is that the magnitude of the foreshock is higher than the magnitude of the aftershock and both values are generally higher than in cases of natural earthquakes (According to the USGS, some large quakes are preceded by foreshocks. The largest quake in a cluster is the mainshock, and those after it are called aftershocks. For more information, see http://quake.wr.usgs.gov/prepare/factsheets/QuakeForecasts/)

- RTS can be immediately noticed during filling periods of reservoirs

- The effect of RTS can be rapid (following the initial filling of the reservoir) or delayed (occurring later in the life of the reservoir)

- There is resistance in the engineering community globally to accept the significant or even existence of RTS. However, groups such as the US Commission on Large Dams have reported that RTS should be considered for reservoirs deeper than 80-100m.

Dr. V. P Jauhari, wrote the following about RIS in a paper prepared for the World Commission on Dams:

“The most widely accepted explanation of how dams cause earthquakes is related to the extra water pressure created in the micro-cracks and fissures in the ground under and near a reservoir. When the pressure of the water in the rocks increases, it acts to lubricate faults which are already under tectonic strain, but are prevented from slipping by the friction of the rock surfaces.” (Jauhari, 1999)

He also makes the following points:

- The scientific explanation for RIS is still not well understood and is therefore not possible to predict.

- Reservoirs can increase the frequency of earthquakes in areas with a previously low occurrence of seismic activity.

See the following table for some examples of RTS by date, location and magnitude.

Name of Dam/ Reservoir	**Location**	**Year**	**Magnitude of Earthquake**
Marathon	Greece	1938	M = 5.7
Hoover	USA	1939	M = 5.0
Lake Crowley	USA	1941	M = 6.0
Kurobe	Japan	1961	M = 4.9
Xinfengjiang	China	1962	M = 6.1
Canelles	Spain	1962	M = 4.7
Kariba	Zambia	1963	M = 6.2
Monteynard	France	1963	M = 4.9
Grandval	France	1963	M = 4.7
Akosombo	Ghana	1964	M = 4.7
P. Colombia/Volta Grande	Spain	1964	M = 4.1
Kremasta	Greece	1966	M = 6.2
Benmore	N. Zealand	1966	M = 5.0
Piastra	Italy	1966	M = 4.4
Koyna	India	1967	M = 6.3
Banjina-Basta	Yugoslavia	1967	M = 4.5 - 5.0
Kastraki	Greece	1969	M = 4.6
Nanshui	China	1970	M = 2.3
Kerr	USA	1971	M = 4.9
Vouglans	France	1971	M = 4.4
Qianjin	China	1971	M = 3.0
Nurek	Tajikistan	1972	M = 4.6
Zhelin	China	1972	M = 3.2
Danjiangkou	China	1973	M = 4.7
Shenwo	China	1974	M = 4.8
Clark Hill	USA	1974	M = 4.3
Nanchong	China	1974	M = 2.8
Huangshi	China	1974	M = 2.8
Oroville	USA	1975	M = 5.7
Manicouagan	Canada	1975	M = 4.1
Lake Pukaki	N. Zealand	1978	M = 4.6
Monticello	S. Carolina	1978	M = 4.1
Hunanzhen	China	1979	M = 2.8
Aswan	Egypt	1981	M = 5.3
Srinakharin	Thailand	1983	M = 5.9
Bhatsa	India	1983	M = 4.9

Dengjiaqiao	China	1983	M = 2.2
Shengjiaxia	China	1984	M = 3.6
Khao Laem	Thailand	1985	M = 4.5
Wujiangdu	China	1985	M = 2.8
Lubuge	China	1988	M = 3.4
Dongjiang	China	1991	M = 3.2
Tongjiezi	China	1992	M = 2.9
Killari or 'Latur'	SW India	1993	M = 6.1
Dahua	China	1993	M = 4.5
Geheyan	China	1993	M = 2.6
Yantan	China	1994	M = 3.5
Shuikou	China	1994	M = 3.2

Sources: Gupta, Harsh K., 2002. "A review of recent studies of triggered earthquakes by artificial water reservoirs with special emphasis on earthquakes in Koyna, India." Earth-Science Reviews 58 279–310.

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Howard, C.D.D., 2000. Operations, Monitoring and Decommissioning of Dams, Thematic Review IV.5 prepared as an input to the World Commission on Dams, Cape Town, www.dams.org

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USGS Auburn Project Review Team, "Review of seismic-hazard issues associated with the Auburn Dam project, Sierra Nevada foothills, California." USGS, 1996, http://pubs.usgs.gov/of/1996/of96-011/induced.html.

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